

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT WE, YOSHIHISA SOEDA, a citizen of Japan residing at Kanagawa, Japan and YOSHIKAZU INOUE, a citizen of Japan residing at Kanagawa, Japan have invented certain new and useful improvements in

IMAGE READING DEVICE AND IMAGE FORMING APPARATUS

of which the following is a specification:-

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally relates to an image reading device and an image forming apparatus in which a reference voltage used when A-D conversion is performed on an output of a photoelectric device is variable.

2. Description of the Related Art

In general, in an image reading device of a copier, a facsimile machine or the like, an original is exposed by a light source, a thus-obtained reflected light from the original is imaged onto a CCD image sensor. Thus, the image of the original is read, and, thus-obtained analog image data is A-D converted into digital data of 8 bits, for example.

In such a case, the CCD image sensor has a white shading function and a black shading function in general so that a dynamic range of an A-D converter can be used widely even if there occurs variation in sensitivity of the CCD image sensor, and variation in signal component due to dark current, for respective pixels. With regard to these functions, various methods have been proposed in Japanese Laid-Open Patent Applications Nos. 62-235871, 63-18763, 9-9056, 11-27522

and so forth, for example.

With regard to the black shading correction,
in an image reading device in which an image of an
original is formed on a CCD image sensor through a most
5 general reduction (not unity magnification) optical
system, when the CCD image sensor itself has always
shaded black dummy pixels at a part thereof, black dummy
output to be used for the black shading correction is
always available, and, data (data for the black
10 correction) of a reference black level for the black
shading correction is always provided for each scan line.
Therefore, even in such a case where the reference
voltage of the A-D converter is variable, for example, a
background removal function is provided such that the
15 upper limit value of the reference voltage of the A-D
converter which converts the read analog image data into
digital data is made to follow the peak value of the
read image data so that the tone of the background of a
sheet of the original image may be cut off/removed from
20 the image data, the data for the black correction (black
correction data) used for the black shading correction
can be made variable according to the variable reference
voltage.

Thus, as a result of the black correction
25 data being provided for each scan line, the black

correction data can be made variable according to the reference voltage, even in such a case where the background removal function is provided in which the reference voltage of the A-D converter is variable.

5 However, in an image reading device employing a CCD image sensor not having such a measure as to provide the black correction data for each scan line or in a system which performs all pixel correction, it is necessary that the black correction data is generated
10 for one scan line as a result of taking an image from the CCD image sensor with a fixed reference voltage applied to the A-D converter during an interval during which the light source is turned off before the original or a white reference plate is read, and then is stored
15 in a memory. Therefore, in a case where the original is read with the variable reference voltage used by the A-D converter or the different reference voltages are used for reading of the white reference plate and the original, it is not possible to obtain the black
20 correction data variable according to the reference voltage of the A-D converter, because the black correction data is maintained in the memory as mentioned above.

 A digital black level value $D0_b$ obtained when
25 an analog black level value V_b is converted through an

8-bit A-D converter using the reference voltage Vref0 can be expressed by the following formula (1):

$$D0_b = \text{INT}[Vb/Vref0 \times 255] \quad \dots (1)$$

5

where INT[] means the value obtained from rounding off the value enclosed by [] to the decimal point, also hereinafter. Then, the data D0_b is stored and maintained in a predetermined memory to be used as the

10 black correction data. As shown in the above formula (1), it can be seen that the black correction data D0_b depends on the reference voltage Vref0.

Image data Dshb obtained through the black shading correction from original image data D0_G is
15 calculated by the following formula:

$$Dshb = D0_G - D0_b$$

However, in this case,

20

$$Dshb = \text{INT}[Vw/Vref1 \times 255] - \text{INT}[Vb/Vref0 \times 255] \quad \dots (2)$$

where Vw denotes a voltage of the analog image data
25 obtained when the original is read, and Vref0 denotes

the reference voltage of the A-D converter at this time.
Thus, the reference voltage of the A-D converter is
different between the case of detecting the reference
black tone level and the case of reading the original,
5 and, by using the digital image data obtained by using
the different reference voltages of the A-D converter,
the calculation of the black shading correction is
performed. Thereby, precise calculation cannot be
achieved.

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SUMMARY OF THE INVENTION

An object of the present invention is to
enable the black correction reference data according to
the reference voltage to be obtained even when the
15 reference voltage of the A-D converter varies, and thus,
the black-level correction can be performed precisely.

Another object of the present invention is to
enable such precise black level correction to be
achieved even in a case where the photoelectric device
20 is of a type of not having an empty transfer part.

Another object of the present invention is to
enable the black level correction to be performed
precisely even in a case where a unity magnification
contact-type sensor not providing the black correction
25 reference data for each scan line is used, and, also,

the reference voltage of the A-D converter is different between a case of detecting the black correction reference data and a case of reading an original.

Another object of the present invention is to
5 achieve the above-mentioned objects through a simple circuit configuration.

An image reading device according to the present invention comprises:

- 10 a photoelectric device provided with an empty transfer part;
 - an A-D converter performing A-D conversion on an output signal for each pixel of the photoelectric device;
 - a reference voltage varying part varying a
15 reference voltage of the A-D converter;
 - a detecting part detecting a black correction reference data from output for each pixel of the photoelectric device;
 - a black shading correcting part subtracting
20 the black correction reference data from digital image data obtained from the output signal for each pixel of the photoelectric device when an image is read by the A-D converter having the reference voltage set therein;
 - and
 - 25 a correcting part correcting the black

correction reference data by a ratio of an output level
of the empty transfer part obtained through the A-D
converter when the black correction reference data is
detected and an output level of the empty transfer part
5 obtained through the A-D converter when the image is
read.

Thereby, even if the reference voltage of the
A-D conversion is different between the detection of the
black correction reference data and essential reading of
10 the image, black level correction (or black shading
correction) can be performed precisely.

An image reading device according to another
aspect of the present invention comprises:

- a photoelectric device;
- 15 a empty transfer part output generating part
falsely generating an output of empty transfer part of
the photoelectric device by outputting a predetermined
voltage in predetermined timing;
- an A-D converter performing A-D conversion on
20 an output signal for each pixel of the photoelectric
device;
- a reference voltage varying part varying a
reference voltage of the A-D converter;
- a detecting part detecting a black correction
25 reference data from output for each pixel of the

photoelectric device;

a black shading correcting part subtracting
the black correction reference data from digital image
data obtained from the output signal for each pixel of
5 the photoelectric device when an image is read by the A-
D converter having the reference voltage set therein;
and

a correcting part correcting the black
correction reference data by a ratio of an output level
10 of the empty transfer part output generating part
obtained through the A-D converter when the black
correction reference data is detected and an output
level of the empty transfer part output generating part
obtained through the A-D converter when the image is
15 read.

Thereby, even if the reference voltage of the
A-D conversion is different between the detection of the
black correction reference data and essential reading of
the image, black shading correction can be performed
20 precisely. Further, even when the photoelectric device
does not have the empty transfer part, such a precise
black level correction is enabled.

The photoelectric device may comprise a unity
magnification contact-type sensor which receives
25 reflected light from an original through a unity

magnification optical system.

Thereby, even employing the unity magnification contact-type sensor which can provide no black correction reference data for each scan line, 5 black shading correction can be performed precisely, even if the reference voltage of the A-D conversion is different between the detection of the black correction reference data and essential reading of the image.

The correcting part may comprise:

10 a first adding circuit calculating a sum of output levels of the empty transfer part for predetermined pixels obtained when the black correction reference data is detected;

a second adding circuit calculating a sum of 15 output levels of the empty transfer part for predetermined pixels obtained when the image is read;

a multiplying circuit multiplying the sum output from the second adding circuit with the black correction reference data;

20 a dividing circuit dividing the result of multiplication output from the multiplying circuit by the sum output from the first adding circuit, and outputting the result of the division as the black correction reference data after the correction.

25 Thereby, it is possible to achieve the image

reading device according to the present invention with a simple circuit configuration.

The correcting part may alternatively comprise:

5 a first adding circuit calculating a sum of falsely generated output levels of empty transfer part from the empty transfer part output generating part for predetermined pixels obtained when the black correction reference data is detected;

10 a second adding circuit calculating a sum of falsely generated output levels of empty transfer part from the empty transfer part output generating part for predetermined pixels obtained when the image is read;

15 a multiplying circuit multiplying the sum output from the second adding circuit with the black correction reference data;

20 a dividing circuit dividing the result of multiplication output from the multiplying circuit by the sum output from the first adding circuit, and outputting the result of the division as the black correction reference data after the correction.

Thereby, also by this configuration, it is possible to achieve the image reading device according to the present invention with a simple circuit configuration.

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The correcting part may alternatively
comprise:

a first adding circuit calculating a sum of
output levels of the empty transfer part for
5 predetermined pixels obtained when the black correction
reference data is detected;

a second adding circuit calculating a sum of
output levels of the empty transfer part for
predetermined pixels obtained when the image is read;

10 a microcomputer multiplying the sum output
from the second adding circuit with the black correction
reference data; and

dividing the result of the multiplication by
the sum output from the first adding circuit, and
15 outputting the result of the division as the black
correction reference data after the correction.

Thereby, it is possible to achieve the image
reading device according to the present invention with a
simple circuit configuration.

20 The correcting part may alternatively
comprise:

a first adding circuit calculating a sum of
falsely generated output levels of empty transfer part
from the empty transfer part output generating part for
25 predetermined pixels obtained when the black correction

reference data is detected;

a second adding circuit calculating a sum of
falsely generated output levels of empty transfer part
from the empty transfer part output generating part for
5 predetermined pixels obtained when the image is read;

a microcomputer multiplying the sum output
from the second adding circuit with the black correction
reference data; and

dividing the result of the multiplication by
10 the sum output from the first adding circuit, and
outputting the result of the division as the black
correction reference data after the correction.

Thereby, it is possible to achieve the image
reading device according to the present invention with a
15 simple circuit configuration.

An image forming apparatus according to the
present invention comprises:

the above-mentioned image reading device; and
an image forming device forming an image on a
20 sheet based on the image data read by the image reading
device.

Other objects and further features of the
present invention will become more apparent from the
following detailed description when read in conjunction
25 with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 generally shows a side elevational sectional view of an image reading device in a first embodiment of the present invention;

5 FIG. 2 shows a block diagram of an image reading unit of the image reading device shown in FIG. 1;

FIG. 3 shows a circuit diagram of a reference control circuit shown in FIG. 2;

10 FIG. 4 shows a circuit diagram of a black correcting circuit shown in FIG. 2;

FIG. 5 shows timing charts of respective signals used in the configurations shown in FIGS. 2, 3 and 4;

15 FIG. 6 shows another example of the circuit diagram of the black correcting circuit shown in FIG. 2;

FIG. 7 shows a block diagram of an image reading unit of an image reading device in a second embodiment of the present invention;

20 FIG. 8 generally shows a block diagram of a copier in a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows a side elevational sectional view
25 of an image scanner in a first embodiment of the present

invention. The image scanner 1 includes a flat-bed scanner 2 well-known as a general image reading device, and an automatic document feeder (ADF) 3 disposed above the flat-bed scanner 2.

5 The ADF 3 includes a tray 5 on which original paper 4 is placed. The original paper 4 placed on the tray 5 is divided into individual pages thereof through a well-known mechanism, page by page, each page is conveyed through a conveying path 6, and, then, on a
10 contact glass 7, an image thereof on the obverse side thereof is read by the flat-bed scanner 2. Then, this page of the original paper 4 is ejected to a paper ejecting tray 10.

 Further, a contact-type image sensor 8 is
15 disposed in the above-mentioned conveying path 6, scans the page of the original paper 4 conveyed through the conveying path 6 by exposure, and, thereby, reads an image of the reverse side of this page.

 A white reference plate 9 is provided opposite
20 to the contact-type image sensor 8 and is used as a white reference for correcting a variation for one scan line in a main scanning direction such as a variation in performances of a light source (LED array 11 shown in FIG. 2) itself for exposure and scanning built in the
25 contact-type image sensor 8, a variation thereof due to

temperature and/or aging thereof, and so forth, before the above-mentioned reading operation by the contact-type image sensor 8 is performed.

The contact-type image sensor 8 is a unity
5 magnification contact-type sensor which receives reflected light from the page of the original paper 4 through a unity magnification optical system. When the above-mentioned white reference plate 9 is read by the contact-type image sensor 8, the gain of a variable gain
10 amplifier included in the contact-type image sensor 8 is adjusted so that the peak value of the reading output from the contact-type image sensor 8 becomes a predetermined target value. After the contact-type image sensor 8 reads the white reference from the white
15 reference plate 9, the page of the original paper 4 is conveyed there, and the image data thereof is read by the contact-type image sensor 8.

FIG. 2 shows a block diagram of an image
reading unit including the above-mentioned contact-type
20 image sensor 8 included in the image scanner 1 shown in FIG. 1.

In FIG. 2, when the white reference plate 9 or the page of the original paper 4 is irradiated by the LED array 11 of the contact-type image sensor 8, the
25 reflected light therefrom is received by sensors 12

acting as photoelectric devices which thus read the image thereof. The image data output from each of the sensors 12 is sampled by a respective one of sample-hold (S/H) circuits 13, and, then, is held thereby until the
5 subsequent sampling operation is performed.

The output of each of the S/H circuits 13 is input to an input terminal V_{in} of a respective one of A-D converters 14. A reference value is input to the other input terminal V_{ref} of each of the A-D converters
10 14. Then, the A-D converter 14 determines a level of the input V_{in} with respect to the reference value V_{ref} . Thus, the voltage input to the input terminal V_{in} is A-D converted by the A-D converter 14 so that corresponding digital image data is obtained thereby and output from
15 the A-D converter 14.

The digital image data output from the respective A-D converters 14 undergoes in-line processing by an in-line processing circuit 15 such that the sequence of the digital image data is controlled so
20 that the thus-obtained digital image data is such as that obtained from one-chip sensor.

Then, the thus-obtained digital image data undergoes black shading correction performed by a black correcting circuit 16 such that previously calculated
25 black correction reference data is subtracted from the

given digital image data. The image data having undergone the black shading correction then undergoes white shading correction performed by a shading correcting circuit 17 based on the shading data read from the above-mentioned white reference plate 9 as mentioned above. Then, the thus-obtained image data is output to a signal processing part, not shown in the figure, of the image scanner 1. Further, the image data output from the in-line processing circuit 15 is also input to a reference control circuit 18.

FIG. 3 shows a block diagram of the reference control circuit 18 shown in FIG. 2.

As shown in FIG. 3, the digital image data having undergone the in-line processing so as to be combined together to become a scan line of image data by the in-line processing circuit 15 has noise thereof removed therefrom by an averaging circuit 21. The image data having had the noise removed by the averaging circuit 21 is compared with a predetermined threshold by a comparator 22. Then, when the image data is higher than the predetermined threshold, the comparator 22 outputs an H signal while the comparator 22 outputs an L signal when the image data is lower than the predetermined threshold.

The H/L signal thus output from the comparator

22 is converted into analog data by a D-A converter 23, and, the peak value of this analog data is detected by a peak hold (P/A) circuit 24 and is used as the reference voltage (Vref) for the A-D converters 14.

5 Three sorts of voltages are prepared to be used as the reference voltage (Vref) for the A-D converters 14, and, selection therefrom is made according to a current mode of the image scanner 1. In a mode in which a background removal function is used
10 such that a tone of a background of a page sheet of the original paper 4 is removed, the output value (reference voltage Vref_AE) of the P/H circuit 24 is used as Vref for the A-D converters 14.

 In a mode in which the above-mentioned
15 background removal function is not used, a predetermined value for the white reference plate 9 and a predetermined value for the original paper 4 are D-A converted into reference voltages Vref0 and Vref1 by D-A converters 25 and 26, respectively, and appropriate one
20 of them is used as the reference voltage Vref of the A-D converter 14. Selection from these three sorts of reference voltages Vref_AE, Vref1 and Vref0 is made as a result of switches 27, 28 or 29 being selectively closed by a gate signal WTGT, DOGGT, or AEMODE output from a
25 gate signal generating circuit 19 (see FIG. 2).

A gate signal PWIND shown in FIGS. 2 and 3 is used for determining an interval for reading the background of the page sheet of the original paper 4 in the averaging circuit 21. Gate signals SHGT and SFGATE (see FIG. 5) are control signals for the white shading correction in the shading correcting circuit 17.

Further, an inverter 30 inverts the gate signal AEMODE, and the thus-obtained inverted signal is used for closing a switch 31, so as to connect the P/H circuit 24 to the ground and resets it. Furthermore, with regard to further details of the circuits shown in FIGS. 2 and 3, see Japanese Laid-Open Patent Application No. 9-224156.

The image data Dshb0 obtained after the above-mentioned black shading correction is performed by the black correcting circuit 16 is calculated by operation according to the following formula (3):

$$Dshb0 = D0_G - D0_b \times Vref0/Vref1 \quad \dots (3)$$

This formula (3) can be rewritten into the following formula (4):

$$Dshb0 = \frac{INT[Vw/Vref1 \times 255] - INT[Vb/Vref0 \times 255]}{Vref0/Vref1}$$

$$= \text{INT}[\text{Vw}/\text{Vref1} \times 255] - \text{INT}[\text{Vb}/\text{Vref1} \times 255]$$

$$= \text{INT}[(\text{Vw}-\text{Vb})/\text{Vref1} \times 255] \quad \dots (4)$$

where D0_G denotes the image data before the black shading correction is performed; Vw denotes the reading level voltage obtained from reading the page of the original paper 4; Vb denotes analog black level voltage which will be described later; D0_b denotes the digital level value obtained from A-D converting the black level voltage Vb; and Vref0 and Vref1 denote the reference voltages for the 8-bit A-D converters 14 (Vref0 is used for the black level voltage Vb while Vref1 is used for the reading level voltage Vw of the original paper 4).

Thus, as can be seen therefrom, it is possible to obtain the digital image data having undergone the precise black shading correction by using black correction reference data (D0_b \times Vref0/Vref1) according to the reference voltage Vref1 for the A-D converters 14, through the above-mentioned operation.

A digital black level value D0_t1 obtained from A-D converting an empty transfer level voltage Vt1 which is an analog output of an empty transfer part ETP (black dummy pixels always shaded and not used for reading an image, corresponding to, for example, the top sensor 12, shown in FIG. 2) of the sensors 12 while the

reference voltage V_{ref} for the 8-bit A-D converters 14 is V_{ref0} , is expressed by the following formula (5):

$$D0_t1 = \text{INT}[V_{t1}/V_{ref0} \times 255] \quad \dots (5)$$

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On the other hand, a digital black level value $D0_t2$ obtained from A-D converting the same empty transfer level voltage V_{t1} while the reference voltage V_{ref} of the 8-bit A-D converters 14 is V_{ref1} , is

10 expressed by the following formula (6):

$$D0_t2 = \text{INT}[V_{t1}/V_{ref1} \times 255] \quad \dots (6)$$

Then,

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$$V_{ref0}/V_{ref1} = D0_t2/D0_t1 = \Sigma D0_t2/\Sigma D0_t1$$

Thus, the ratio of the reference voltages " V_{ref0}/V_{ref1} " can be obtained as the ratio of the reading data from the empty transfer part ETP of the sensors 12.

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Accordingly, a digital black level value $D0_b$ which should be obtained from A-D converting the analog black level voltage V_b with the above-mentioned reference voltage V_{ref1} , with respect to the above-mentioned digital black level value $D0_b$ obtained from

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A-D converting the analog black level voltage V_b with the above-mentioned reference voltage V_{ref0} , can be obtained from the following formula (7):

$$D0_{bw} = D0_b \times \Sigma D0_{t2} / \Sigma D0_{t1} \quad \dots (7)$$

The reason why the ratio of the sums (Σ) for pixels of the above-mentioned empty transfer part ETP is used in the formula (7) is that error is to be reduced.

Thus, it is possible to obtain the black correction reference data $D0_{bw}$ corrected according to the difference in reference voltage V_{ref} of the A-D converters from the reading data from the empty transfer part ETP of the sensors 12. This can be easily achieved by detecting and calculating the ratio of the reference voltages as a digital amount as shown in the formula (7).

The above-mentioned black correcting circuit 16 has a configuration such as to enable the black shading correction according to this method to be executed. FIG. 4 shows a block diagram of the circuit configuration of the black correcting circuit 16, and FIG. 5 shows timing charts of respective signals thereof.

First, when a page of the original paper 4 is fed by the ADF 3, as shown in FIG. 5, a gate signal SLEAD (signal indicating a reading range for the white

reference plate 9) is output from a microcomputer 20,
and, then, a light source turning on signal LED_ON for
tuning on the LED array 11 is made active. In this case,
the black correction reference data is obtained during
5 an active interval of a gate signal BKGT for L1 scan
lines (the interval of L1), from the time the gate
signal SLEAD is made active until the time the light
source tuning on signal LED_ON is made active (so that
the LED 11 is turned on).

10 During the L1 interval, the reference voltage
Vref1 is selected (the gate signal DOCGT is asserted) by
the reference control circuit 18, as the reference
voltage Vref for the A-D converters 14.

The black correction reference data is
15 obtained in the black correction circuit 16, and, during
the interval during which the gate signal BKGT is
asserted, as shown in FIG. 4, averaging is performed for
each pixel by an averaging circuit 41 as follows:

20
$$D0_b(n) = \Sigma D0(n) / L1$$

where:

$D0_b(n)$ denotes the black correction reference
data for n-th pixel;

25 $D0(n)$ denotes the reading data from the sensor

12 for the n-th pixel; and

$\Sigma D0(n)$ denotes the sum of $D0(n)$ for the respective scan lines from 1 through $L1$.

Then, the thus-obtained black correction
5 reference data is stored in a memory 42.

The output level of the above-mentioned empty transfer part ETP of the sensors 12 is taken by an adding circuit 48, the adding circuit 48 performs adding operation on the thus-taken data for the pixels of the
10 empty transfer part ETP, and the adding result ($\Sigma D0_t1$) is output therefrom each time a predetermined clock signal VADJGT is asserted, which is then held by a latch circuit 49 at a negation edge of the signal BKGT. Accordingly, the latch 49 has the value obtained when
15 the reference voltage for the A-D converters 14 is $Vref0$ held therein.

Further, the output level of the empty transfer part ETP of the sensors 12 is taken by an adding circuit 43, and the adding circuit 43 performs
20 the adding operation on the thus-taken data for the pixels of the empty transfer part ETP, and outputs $\Sigma D0_t2$ each time of assertion of the signal VADJGT.

The above-mentioned signal VADJGT is asserted for each scan line, to the empty transfer part ETP (for
25 example, on the order of 16 pixel clock periods).

At the beginning of an interval during which the signal SLEAD indicating a reading operation interval for reading the white reference plate 9 is asserted, the reference voltage Vref0 for the white reference plate 9 is selected as the reference voltage Vref of the A-D converters 14 (the gate signal WTGT is asserted). Then, Then, reading of the white reference plate 9 is started while the LED is turned off. During the interval L1, the black correction reference data is produced, as mentioned above. Then, after that, at a time the signal BKGT is negated after L1, production of the black correction reference data is finished, and the LED array 11 is turned on.

During the interval of assertion of WTGT included in the interval of assertion of SLEAD after negation of BKGT, white shading data is produced in the shading correcting circuit 17 from the thus-read data.

Thereby, all the data needed for the operation of the formula (7) is obtained.

First, a multiplying circuit 44 performs the following multiplication operation:

$$D1_b = D0_b \times \Sigma D0_t2$$

where $\Sigma D0_t2$ is given by the adding circuit 43.

Then, a dividing circuit 45 performs the following division operation:

$$D2_b = D1_b / \Sigma D0_t1$$

5

where $\Sigma D0_t1$ is given by the adding circuit 48, as mentioned above. Thus, the right side of the formula (7) is obtained ($D2_b = D0_bw$).

Thus, the black correction reference data $D0_b$ is corrected by the ratio of the reading data from the empty transfer part ETP which corresponds to the ratio of the reference voltage $Vref0$ for the A-D converters 14 while the black correction reference data is obtained to also the reference voltage $Vref0$ for the A-D converters 14 when the white shading data is obtained, during the $L1$ interval. Accordingly, for reading the white reference plate 9, this ratio is 1, and, thus, no substantial correction is made. This is because, in this time, the reference voltage $Vref$ when producing the black correction reference data is the same as that when producing the white shading data.

Then, in order to perform the essential black shading correction on the data read from the white reference plate 9 during the interval of assertion of WTGT, a subtracting circuit 46 performs the following

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subtraction operation:

$$Dshb = D0_G - D2_b$$

5 Thus, the operation of the formula (3) is completed so that the digital image data D0 undergoes the black shading correction so as to become the black corrected data Dshb to be output from the black correcting circuit 16.

10 In this case, it is also possible to substitute a microcomputer 47 for the multiplying circuit 44, dividing circuit 45 and latch 49, which microcomputer 47 outputs the black level value (corrected black correction reference data $D2_b = D0_bw$)
15 to the subtracting circuit 46 (see FIG. 6).

Then, the signal SLEAD is negated, and reading of the white reference plate 9 and black correction of the thus-obtained image data is finished.

Then, Vref1 is selected as the reference
20 voltage Vref for the A-D converters 14 (gate signal DOCGT is asserted). Then, when the page of the original paper 4 is conveyed to a reading position for the CCD image sensor 8, an SSCAN signal indicating an effective reading range for the conveyed page of the original
25 paper 4 is asserted, the page of the original paper 4 is

read, and the thus-read image data undergoes the black shading correction performed in the black correcting circuit 16 by using the black correction reference data corrected as mentioned above and the white shading correction performed in the white shading correcting circuit 17 by using the above-mentioned white shading data.

In this time, as mentioned above, the output from the empty transfer part ETP of the sensors 12 is obtained through the adding circuit 43 each time of assertion of VADJGT. Then, same as in the case for calculating the white shading data, the operation of correcting the black correction reference data D0_b output from the memory 42, and calculating the corrected black correction reference data (black level value) D2_b (= D0_bw) are performed each time the assertion of VADJGT through the circuits 44 and 45 while the data ED0_t1 corresponding to Vref0 obtained when the black correction reference data D0_b latched at the negation of L1 is provided from the latch 49.

Then, the thus-obtained corrected black correction reference data is used for the above-mentioned essential black shading correction performed by the subtracting circuit 46 on the image data read from the image of the page of the original paper 4. In

this time, the ratio for correcting the black correction
reference data $D0_b$ is the ratio of the reading data
from the empty transfer part ETP which corresponds to
the ratio of the reference voltage $Vref0$ for the A-D
5 converters 14 while the black correction reference data
is obtained to the reference voltage $Vref1$ for the A-D
converters 14 when the effective image data is read.
Accordingly, the black correction reference data is
corrected according to the currently reference voltage

10 The thus-corrected image data is output to the
signal processing part not shown in the figures.

By configuring as described above, it is
possible to perform the black shading correction even
when the original paper 4 is read by using the reference
15 voltage $Vref$ for the A-D converters different from that
used when the black correction reference data is
obtained. Thus, although the reference voltage $Vref0$
for the A-D converters used when the black correction
reference data is obtained is different from the
20 reference voltage $Vref1$ for the A-D converters used when
the original paper 4 is read, or the reference voltage
of the A-D converters varies while the original paper 4
is read, it is possible to perform the black shading
correction at a high accuracy, because the black
25 correction reference data is corrected by using the

reference voltage V_{ref1} used when the original paper 4
(effective data) is read, as can be seen from the
formula (3).

A second embodiment of the present invention
5 will now be described with reference to FIG. 7.

Difference between the above-described first
embodiment and the second embodiment is that, as shown
in FIG. 7, the above-mentioned empty transfer part ETP
is not provided in the sensors 12 in the second
10 embodiment, and, a variable voltage generating circuit
51 and a switch 52 are provided, instead. The switch 52
is opened/closed by a signal VCHGT. The other
configuration is the same as that of the first
embodiment, and description of which is omitted with the
15 same reference numerals given thereto.

In the second embodiment, by asserting the
signal VCHGT, the switch 52 is closed so that a
predetermined voltage is output to the A-D converter 14
of the plurality of A-D converters 14 from the variable
20 voltage generating circuit 51 instead of the output of
the corresponding sensor 12 (ETP, in FIG. 2) and S/H
circuit 13. Thereby, it is possible that the effect
same as that obtained when the empty transfer part (ETP)
were provided in the sensors 12 is obtained as a result
25 of the variable voltage generating circuit 51 providing

a false output of the output of the empty transfer part (ETP).

Accordingly, even when the sensors 12 have no empty transfer part (ETP), it is possible to perform the
5 precise black shading correction same as in the above-described first embodiment.

A third embodiment of the present invention will now be described with reference to FIG. 8.

The third embodiment of the present invention
10 is a copier 61 shown in FIG. 8 as an image forming apparatus. The copier 61 includes the image scanner 1 in any of the above-described first and second embodiments of the present invention, and a printer 62 which forms an image on a paper sheet based on the image
15 data of the page of the original paper 4 read through the image scanner 1. This printer 62 may be of any of various types such as an electrostatic photographic type, an ink-jet type, a sublimation-type thermal transfer type, a silver-bromide photographic type, a direct heat
20 sensitive recording type, a melting-type thermal transfer type and so forth.

The present invention is not limited to the above-described embodiments, and variations and modifications may be made without departing from the
25 scope of the present invention.

The present application is based on Japanese priority application No. 2000-145878, filed on May 18, 2000, the entire contents of which are hereby incorporated by reference.